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19. ABSTRACT (Continue on reverse if necessary and identify by block number) INTRODUCTION. Idiopathic central serous chorioretinopathy (ICSC) is an uncommon disease with the potential to cause loss of visual acuity, decreased color vision, and decreased depth perception. These visual changes may become permanent and require removal of aviators from flight status. METHODS. This study reviews 55 eyes of 47 USAF aviators with ICSC examined at the United States Air Force School of Aerospace Medicine (USAFSAM), Brooks Air Force Base, Texas. Clinical and aeromedical findings, both on initial and on follow-up ophthalmic examination, were studied. RESULTS. Ninety-seven percent of aviators otherwise medically qualified were ultimately returned to flight status. Eighty-four percent attained a final visual acuity of 20/20 or better. On final examination, 86% had normal stereopsis, 85% had normal color vision and 41% had a normal Amsler Grid examination. Overall, 51% had recurrent episodes, 17% had bilateral disease and 13% underwent laser photocoagulation. Visual acuity correlated with active disease and color vision, but not with stereopsis, Amsler Grid or laser photocoagulation. Eyes with a recurrence tended to have a degraded final visual acuity. CONCLUSION. The visual and aeromedical prognosis from a single attack of ICSC is good.

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Generally favorable, but repeated attacks can lead to a significant decrease in visual acuity that may jeopardize flying status. Keywords: Maculopathy, Depth Perception, Fluorescein Angiography. (AW)X

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Clinical Medicine

Central Serous Chorioretinopathy in U.S. Air Force Aviators: A Review

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Idiopathic central serous chorioretinopathy (ICSC) is an uncommon disease with the potential to cause loss of visual acuity, decreased color vision, and decreased depth perception. These visual changes may become permanent and require removal of aviators from flight status. This study reviews 55 eyes of 47 USAF aviators with ICSC examined at the United States Air Force School of Aerospace Medicine (USAFSAM), Brooks AFB, TX. Clinical and aeromedical findings, both on initial and on follow-up ophthalmic examination were studied. Ninety-seven percent of aviators otherwise medically qualified were ultimately returned to flight status. Overall, 51% had recurrent episodes, 17% had bilateral disease, and 13% underwent laser photocoagulation. Visual acuity correlated with active disease, and there was a trend toward poor stereopsis and diminished color vision with worsening visual acuity. Eighty-six percent attained a final visual acuity of 20/20 or better. On final examination, 90% had normal stereopsis, 87% had normal color vision, and 49% had a normal central visual field. Eyes with recurrent disease tended to have degraded final visual acuity, stereopsis, color vision, and central visual field. The visual and aeromedical prognosis from a single attack of ICSC is generally favorable, but repeated attacks can lead to a significant decrease in visual functions that may jeopardize flying status.

IDIOPATHIC CENTRAL serous chorioretinopathy (ICSC) was first described by Von Graefe in 1866, who called it "Recurrent Central Retinitis" (48). A number of articles have detailed the history of this well-described condition and the etiologies proposed (3,5,15,20,22,49,50). It was not until the development of the technique for rapid-sequence photographic fluores-

cein angiography of the fundus in 1961, however, that the pathogenesis of the condition could be confirmed (39). In his landmark article in 1967, Gass demonstrated that a focal process in the choriocapillaries beneath the macula, resulting in increased choroidal vascular permeability, was responsible for the abnormal transudation of fluid and the subsequent serous detachment of the retinal pigment epithelium and the retina (12). The etiology of this condition, however, is still unknown.

ICSC patients are usually healthy adults; their average age is 38-43 years (2,8,29,33,35,38,47). Males are affected more commonly than females in ratios ranging from 2:1 to 7:1 (2,5,8,25,29,32,38,47). Patients usually complain of mildly decreased, blurred, or distorted vision in one eye, although bilateral disease does occur in from 2-30% of patients (4,5,10,13,24,25,27,33,35,36,38,47). They often have the following abnormalities: positive scotoma 83%, metamorphopsia 65-84%, micropsia 37-86%, and Amsler grid changes 95% (33,47). Abnormal color perception is also reported (6,11,21,22,26,34,45,55). Fundus examination usually reveals a circular, serous retinal and retinal pigment epithelial detachment in the macular area involving the fovea. A fluorescein angiogram may demonstrate a focal leak from the choroidal vasculature through Bruch's membrane in from 64-100% of patients (8,16,28,53,54).

The serous detachment and visual symptoms last an average of 3-6 months without treatment (17,23,33,36). Most patients recover good visual acuity; 36-86% obtain a final visual acuity of 20/20 (2,8,10,13,16,17,24,28,29,33,36,38). No medical treatment has proven beneficial (5,13). Photocoagulation of the actual leaking area seals the leak at the retinal pigment epithelium, probably by debridement, and serves to shorten the course of the detachment (1,2,12,16,27,28,31,42,46,51,52,54,56).

Only two papers have dealt with ICSC in flyers. One is a 1972 report from our department (9), and the other is a report from the Israeli Air Force (17).

Over the past 23 years (1964-1987), 47 flyers with a history of ICSC were referred to the Ophthalmology

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Branch at USAFSAM for flying status evaluation. The records of these flyers were reviewed. This paper summarizes our findings and analyzes the reasons which led to our recommendations for, ultimately, returning 97% of the aviators to flight status.

METHODS AND MATERIALS

Patient Selection: The Ophthalmology Branch at USAFSAM serves a consultant function to the USAF Surgeon General for aviators who have been grounded for a disqualifying ocular condition or disease. USAF aviators, also known as flyers, are those personnel required to maintain Flying Class II or III medical standards (i.e., pilots, navigators, other aircrew members and air traffic controllers). Patients were generally referred from their local flight surgeon to USAFSAM once diagnosis, treatment, and resolution or stabilization of the ocular problems had occurred. No treatment was instituted at USAFSAM.

Patient Evaluation: All patients received a full, dilated ophthalmologic examination and special testing that included: Amsler grid; color testing with Pseudo-isochromatic Plates—PIP ($\geq 10/14$ passes); stereopsis testing with the Vision Testing Apparatus—VTA (25 arc seconds passes), Verhoeff device (33 arc seconds passes), or Howard-Dolman device (11 arc seconds passes). Most patients with suspected active disease underwent fluorescein angiography of the ocular fundus.

RESULTS

Patients: Of the 47 aviators, 36 were pilots, 6 were navigators, 4 occupied other crew positions, 1 was an air traffic controller. Of the patients, 19 had only the right eye involved; 20 had only the left eye involved; 8 ultimately had both eyes affected (17%). The mean age at diagnosis was 36.3 years (range 24–49 years). All were male Caucasians. Of the 47 patients, 22 had a smoking history; 22 did not; information was not available on 3.

Although the aviators did not present for acute management, 14 out of 55 eyes (25%) had active disease on initial evaluation as manifested by a leak on fluorescein angiography and/or serous detachment. Out of 55 eyes 24 (44%) were seen within 6 months of the diagnosis. Inactive ICSC was an incidental finding in 7 eyes of 7 aviators (13%).

Of the 55 affected eyes 38 (69%) were seen at least twice. The mean follow-up was 2.3 years with a range from 3 months to 13 years. Twenty-four patients (51%) had a recurrent episode of ICSC. Nine of these suffered a single recurrence in the same eye, seven had multiple recurrences in the same eye, three had a single recurrence in the opposite eye, and five had multiple recurrences in both eyes. Two (5%) had active disease at the time of the most recent examination.

Of the 47 aviators 6 (13%) underwent laser photocoagulation for ICSC (7 eyes). One was treated prior to his first USAFSAM evaluation. One flyer was treated both before and after his first visit. The other four aviators

TABLE I. FREQUENCY OF ICSC SYMPTOMS.

Symptom	# of Eyes	% of Eyes
Blurred Vision	33	70%
Metamorphopsia (distorted images)	14	30%
Micropsia (small images)	8	17%
Central Scotoma	7	15%
Change in color vision	3	6%
Asymptomatic	5	11%

were treated only after their first USAFSAM evaluation. The authors did not recommend or participate in the laser therapy, and no details were available regarding the specifics of the treatments.

Symptoms: Five aviators (11%) were asymptomatic at the time of diagnosis, while the remaining forty-two (89%) complained of one or more symptoms. Table I lists the frequency of ICSC symptoms.

Visual Acuity: Visual acuity was decreased during active disease but improved with resolution of the leak. On the initial evaluation, 82% (45/55) of eyes had 20/20 or better vision; 5 eyes had a visual acuity between 20/20 and 20/30, and the remaining 5 eyes ranged from 20/40 to 20/70. Visual acuity during the acute episode was not available, except for the 14 eyes with active disease at the time of the evaluation. Of the eyes without active ICSC, 90% had 20/20 or better vision, while only 57% of the eyes with active disease had 20/20 or better vision.

Fig. 1 displays the visual acuity from the most recent evaluation (six eyes with active disease were excluded). The visual acuity tended to improve with resolution of the disease, as 86% recovered a visual acuity of 20/20 or better. The laser-treated eyes followed a similar distribution of recovered visual acuity. The laser photocoagulation did not affect the visual outcome of the six flyers treated.

Stereopsis: Abnormal stereopsis was associated with decreased visual acuity. Initial stereopsis testing was obtained on 45 of 47 patients. Only 6 aviators (13%) were not able to pass the VTA-ND, Verhoeff or Howard-Dolman tests; 4 of these had active disease, as well as a visual acuity of 20/30 or worse. However, 11 of the

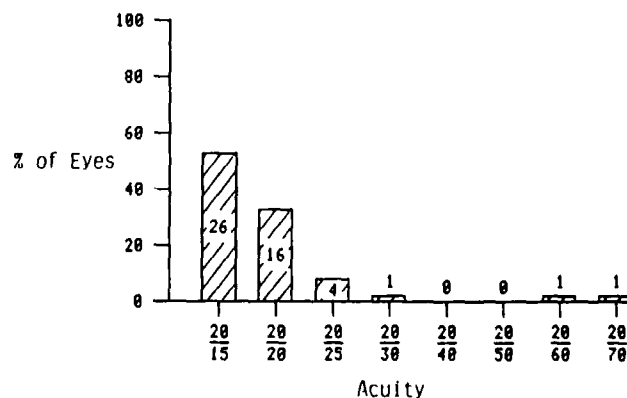


Fig. 1. Recovered visual acuity. The visual acuity distribution from the most recent evaluation is displayed (six eyes with active disease excluded). Percentage of all eyes is listed on the y-axis, and the actual number of eyes is listed within the bar.

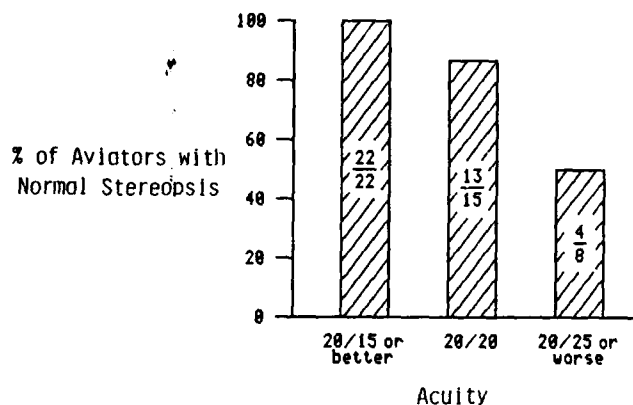


Fig. 2. Visual acuity and stereopsis. The trend of poor stereopsis with decreasing visual acuity is shown. Percentage of aviators with normal stereopsis is plotted for each visual acuity grouping. The ratio of aviators with normal stereopsis to the total number of aviators within each acuity grouping is listed inside the bar.

13 patients with active disease (14 eyes) were tested and 7 (64%) passed.

The bar graph in Fig. 2 depicts the trend of poor stereopsis with decreasing visual acuity. Notice that 100% of the aviators with 20/15 visual acuity were able to pass the stereopsis testing (25 arc sec), while 87% of those with 20/20 visual acuity and only 50% of those with 20/25 or worse visual acuity were able to pass. The visual acuity groupings were chosen because 20/15 is the best corrected visual acuity of a majority of aviators, 20/20 is required to remain on flying status, and 20/25 or worse requires a waiver to continue flying duties.

Stereopsis tended to recover with resolution of the disease, as 90% of aviators with inactive disease ultimately achieved 25 arc sec.

Color Vision: Eyes with abnormal color vision were associated with diminished visual acuity. Out of 55 eyes, 54 were initially tested monocularly with pseudo-isochromatic color plates (PIP). Two of these eyes had mild congenital deuteranopia; they are eliminated from the statistical calculations. Forty-two eyes (81%) were normal. Nine eyes (17%) had abnormal color vision in the affected eye, incorrectly identifying two or more color plates than the healthy eye. One eye failed, incorrectly identifying 5 or more out of 14 plates. Of 14 eyes with active disease, 13 were tested; 5 (38%) had normal color vision; 8 (62%) had abnormal color vision.

The bar graph in Fig. 3 depicts the trend of diminishing color vision with decreasing visual acuity. Notice that 89% of the eyes with 20/15 visual acuity had normal color vision, while 81% of the eyes with 20/20 visual acuity and only 33% of the eyes with 20/25 or worse visual acuity had normal color vision.

Color vision tended to recover with resolution of the disease, as 87% of eyes with inactive disease ultimately retained normal color vision.

Central Visual Field: Metamorphopsia on Amsler grid testing did not correlate with visual acuity or active disease. The central visual field was tested with an Amsler grid on 43 of the 55 involved eyes (78%); 12 eyes (28%) were normal, while 31 (72%) showed distortion. Of the 14 eyes with active disease, 12 were tested; 3

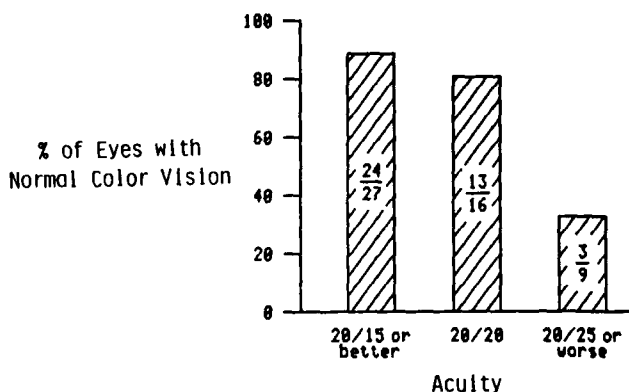


Fig. 3. Visual acuity and color vision. The trend of diminishing color vision with decreasing visual acuity is shown. Percentage of eyes with normal color vision is plotted for each visual acuity grouping. The ratio of eyes with normal color vision to the total number of eyes within each acuity grouping is listed inside the bar.

eyes (25%) were normal, while 9 (75%) showed metamorphopsia.

The bar graph in Fig. 4 demonstrates the variable relationship between central visual field distortion and visual acuity.

Central visual field distortions tended to normalize over time. Ten eyes demonstrated a change, eight from abnormal (metamorphopsia) to normal and two from normal to abnormal. Of eyes with inactive disease 49% recovered a normal central visual field.

Fluorescein Angiography: Fluorescein angiography was performed on 35 of the 55 eyes (64%). Fourteen eyes (40%) had an abnormal angiogram, demonstrating either a leak or serous detachment (i.e., active disease). Eyes with inactive disease demonstrated retinal pigment epithelial defects of varying degrees.

Recurrence: Eyes with recurrent episodes of ICSC tended to have worse visual acuity, stereopsis, color vision, and central visual fields. The bar graph in Fig. 5 displays the effect of multiple episodes of ICSC on these psychophysical functions. The six aviators with active disease on the final evaluation are eliminated. Notice, as one moves from one episode of ICSC to two episodes

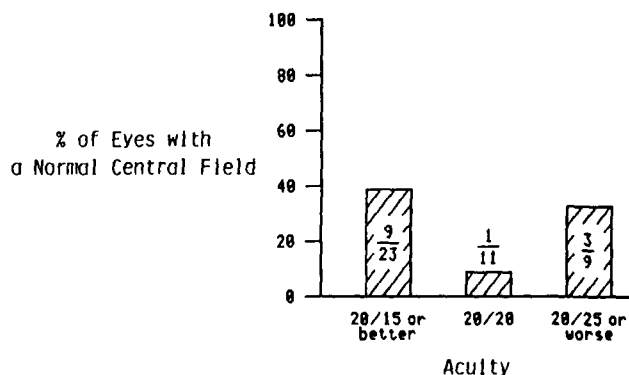


Fig. 4. Visual acuity and central field. The variable relationship between central visual field distortion and visual acuity is shown. Percentage of eyes with a normal central field by Amsler grid testing is plotted for each visual acuity grouping. The ratio of eyes with a normal central field to the total number of eyes within each acuity grouping is listed inside the bar.

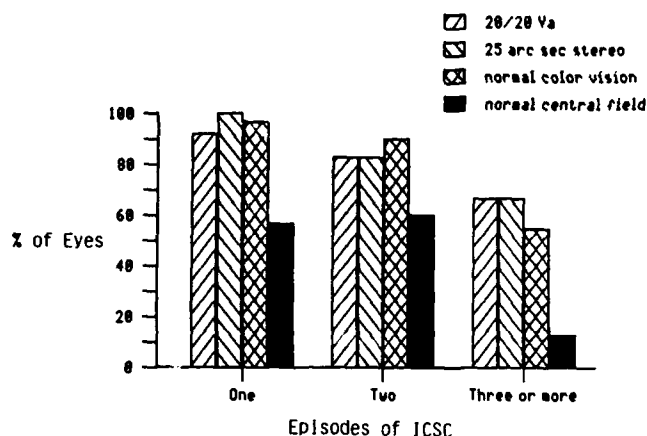


Fig. 5. Effect of recurrence on psychophysical functions. The trend toward worse visual acuity, stereopsis, color vision, and central visual field with increasing episodes of ICSC is shown. Percentage of eyes with a normal visual function is plotted against the number of episodes of ICSC.

and then to three, that each of the psychophysical functions is normal in a lower percentage of aviators: 20/20 or better visual acuity goes from 92% to 83% to 67% of aviators; normal stereopsis from 100% to 83% to 67%; normal color vision from 97% to 90% to 55%; normal visual field from 57% to 60% to 13%.

Aeromedical Disposition: Waiver consideration was not applicable in four aviators who retired. Five others were grounded for medical reasons other than ICSC and are not discussed here. Fig. 6 contains an aviator flow chart of the aeromedical disposition of the remaining 38 aviators. Beginning at the left side of the chart, 31 (82%) initially received a waiver to continue flying duties. Of these 31 flyers, 3 had an eye with a visual acuity worse than 20/20. One was a pilot with 20/30 visual acuity in one eye, who had normal stereopsis, normal color vision, no Amsler grid changes and inactive disease. Each of the other two flyers had one eye with active disease. One was a flight engineer whose affected eye had 20/50 vision, and the other was a pilot whose affected eye had 20/30 visual acuity. Four other aviators had an eye with active disease and were granted waivers, but in each the visual acuity was 20/20 or better. Continuing to the right, 3 of the 31 aviators (10%) initially granted a waiver, were subsequently grounded for recurrent ICSC. They ultimately returned to flying status.

Return to the left of the flow chart and notice that

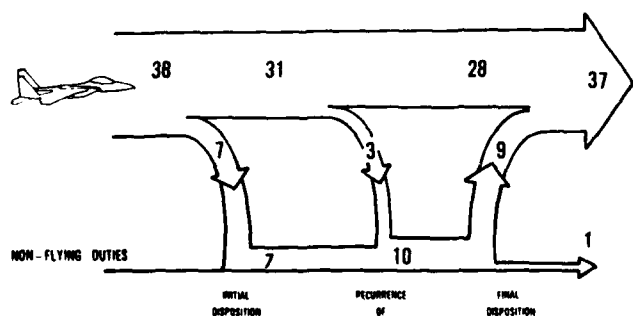


Fig. 6. ICSC aviator flow chart. The chart depicts the flow of aviators from flying to non-flying duties, and then back to flying status.

seven aviators (18%) did not initially receive a waiver solely due to active ICSC. They were placed in DNIF (Duty Not Involving Flying) status. The visual acuities in their diseased eyes were 20/20+ in three, 20/25 in one and 20/40 in three. Six of the seven ultimately returned to flying status.

Only one aviator out of thirty-eight (3%) did not return to flying status because of ICSC. He was an air traffic controller initially disqualified because of continued awareness of central visual distortion. He did not return for a re-evaluation.

ICSC Not Referred to USAFSAM

Review of the USAF waiver file revealed that ICSC was diagnosed in 53 other aviators not referred to USAFSAM for evaluation. They received waivers either from their major air command surgeon general or the USAF Surgeon General. Of these, 28 were pilots, 13 were navigators, 6 were flight engineers, and 6 occupied other crew positions. Twenty-two (42%) are still on active duty. Forty-seven (89%) were male; however, sex was not noted for the other six. Forty (75%) were Caucasian. The race is annotated as "other" in seven aviators and not listed in six.

Of the 53 aviators, 11 (21%) received an indefinite waiver, and 40 (75%) received a temporary waiver; the other 2 were disqualified from flying duties for medical problems other than ICSC. Six of the aviators (11%) also received a waiver for decreased visual acuity. Six (11%) carried the diagnosis of posterior subcapsular cataract.

DISCUSSION

Flying Waivers: Our data continue to demonstrate that most aircrew members can be safely returned to full flying duties after single and multiple episodes of ICSC. In our 1972 report, 81% of flyers were visually qualified to return to flight status, although one of these was disqualified for other medical reasons (9). This continues to be the case. Initially, 82% of the aviators were felt to be qualified for flying. Those with active disease were encouraged to await resolution, with or without laser treatment, and return for re-evaluation. Only one aviator who was otherwise medically acceptable did not receive a waiver. He did not return for follow-up. Our ultimate cockpit return rate for experienced aviators was, therefore, 97%. Gross *et al.*, in 1986, reported a cockpit return rate of 81% (17).

Initial Symptoms: Our data support the findings of others quoted earlier that the most common symptoms during an attack of ICSC are blurred vision, metamorphopsia, micropsia, and central visual field changes.

Final Visual Acuity: The percentage of eyes with inactive disease having a final visual acuity of 20/20 or better was 86%.

Other studies have shown that the final visual acuity is statistically unaffected by laser photocoagulation of the choroidal leak (8,10,16,28,29,41,52,56). Our data, while not conclusive, further demonstrate that laser treatment does not affect final visual acuity.

Dellaporta (8) has shown that the percentage of eyes with a severe decrease in final acuity did not differ be-

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tween untreated and laser-treated eyes (8% vs. 10%). In our study, only one patient who received laser therapy, and one patient who did not, had a residual visual acuity worse than 20/40.

Amsler Grid: Central visual field defects can persist. Our finding of a residual central visual field abnormality, as measured by the Amsler grid, in 51% of eyes with inactive disease is in accord with other reports—81% Natsikos (37) and 89% M. L. Klein (24). Even with recovery of good visual acuity (20/30 or better) 10–20% of patients report troublesome residual central field changes (25,38). It should be noted that our patients obtain a significant secondary benefit (continuing on flying status) from *not* calling attention to adverse symptoms.

Stereopsis: No data exist in the literature regarding stereopsis, except for our department's 1972 report (9).

Our present data demonstrate that 90% of aviators with inactive disease on final examination have "normal" stereopsis, using one of three tests described.

Color Vision: Color abnormalities in ICSC have been studied. Mori, in 1916, was the first to note a shift of the Rayleigh Equation toward the red with the Nagel Anomaloscope (34). Subsequent reports have also demonstrated this pseudoprotanomalous pattern in patients with active disease (6,21,45,55).

Kitahara first noted a blue-yellow defect in 1936 (22). Others have also demonstrated a blue-yellow Tritan axis on the Farnsworth Munsell 100-Hue test in patients with active disease (6,11,45,55). Folk reported that 38% of his ICSC patients had a Tritan defect and 46% had a nonspecific pattern (11).

Krill found that, in macular disease, performance on color tests paralleled the visual acuity (26). Patients with 20/30 acuity usually had mild abnormalities on the Nagel anomaloscope and sometimes on the 100-Hue, and an acuity of 20/40 or worse resulted in abnormalities on both tests in most cases.

Our data support Krill's findings, in that normal color vision correlated strongly with good visual acuity.

Recurrences: Reports have shown that the recurrence rate for untreated eyes varies between 7.7 and 57% (5,13,17,23–25,29,33,38,47). The recurrence rate for laser-treated eyes in two studies was 19% and 6% (14,55). Studies that have compared untreated and laser-treated eyes give conflicting results; 30–60% untreated vs. 0–50% treated (8,10,16,36,39,53,54). Our data support the conclusion that the rates are similar.

Electrophysiology: Electrophysiologic abnormalities have been reported in ICSC. In active disease, the visual evoked potential (VEP) latency may be prolonged (11,18,40,44), the electroretinogram (ERG) "a" wave amplitude may be decreased (40), and the critical flicker-fusion frequency may be decreased (11,18). With resolution of the serous detachment, published reports draw conflicting conclusions as to whether the abnormalities of critical flicker-fusion and VEP persist (18) or resolve (11,44).

Clinically, a relative afferent pupillary defect has been noted in 15 of 18 involved eyes (11), the Pulfrich phenomenon has been demonstrated (19), and the photostress recovery time is prolonged (30,37,43). These all

return to normal with resolution of the serous detachment.

Therefore, even though vision may be normal during an attack of ICSC, the eye does not function normally.

Recommendations

USAF Regulation 160-43 mandates that the aviator must be temporarily grounded for the active ocular disease. This is appropriate considering the abnormalities in visual acuity, stereopsis, color vision, Amsler grid, and electrophysiology testing present during active episodes. Major criteria which may adversely affect a recommendation for returning a flyer to the air have not changed. These criteria include active disease, a decrease in visual acuity, central visual field defects and loss of stereopsis.

Residua of the condition which may impact on the decision, but which in themselves do not prevent a return to flight status, include minor Amsler grid changes, small visual field defects, and monocular color vision deficits.

Laser photocoagulation is recommended in accordance with the principles of Gass (13) and De Laey (7):

- Serous detachment longer than 4 months
- Site of leakage outside the capillary-free zone
- Recurrent serous detachment in an eye with a permanent visual deficit due to ICSC
- Initial serous detachment in the second eye and permanent loss of central vision in the opposite eye due to prior ICSC

Due to potentially vision-threatening complications, laser photocoagulation is done only after full patient counseling and informed consent.

Summary

The functional recovery of flyers with ICSC is generally good—86% attained 20/20 or better visual acuity; 90% had 25 arc sec of stereopsis; 87% recovered normal color vision; 49% retained a normal central visual field. However, the recurrence rate was 51%, and each of the psychophysical functions worsened with recurrent episodes of ICSC. The aeromedical disposition of experienced flyers is generally good. Only 1 of 38 did not return to flight status due to ICSC.

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